Northeast Fisheries Science Center Reference Document 92-06

Harbor Porpoise in Eastern North America: Status and Research Needs

Results of a scientific workshop held May 5-8, 1992 at the Northeast Fisheries Science Center Woods Hole, MA USA

NOAA/National Marine Fisheries Service
Northeast Fisheries Science Center
Conservation and Utilization Division
Woods Hole, MA 02543-1097

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Edited by
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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Executive Summary

A scientific workshop evaluated the status of harbor porpoise populations in eastern North America, May 5-8, 1992, at Northeast Fisheries Science Center in Woods Hole, Massachusetts. Information was reviewed on population structure, reproductive rates, population size, levels of by-catch, and ecological relationships. The workshop favored a hypothesis of three populations in the area, identified as the Newfoundland, the St. Lawrence, and the Gulf of Maine-Bay of Fundy populations. The workshop did not reject, however, an alternative hypothesis of only one population in the entire region. No new information on reproductive and natural mortality rates were available, and the workshop relied on a previous discussion within the Scientific Committee of the International Whaling Commission as being the most complete summary of potential and likely rates of population increase. An approach to refining uncertainty about these rates was outlined.

New data relative to population size were presented based on shipboard surveys in the Gulf of Maine and Bay of Fundy in August 1991. Estimates based on these data were reviewed and the workshop agreed that best estimates of abundance of porpoise in this area is approximately 45,000 (95 percent CI 19,000 to 80,000). No useful estimates of abundance for the other two populations exist. New data were presented on the levels of by-catch for some fisheries, including the U.S. Gulf of Maine sink gillnet fishery and sink gillnet fisheries in Newfoundland and the St. Lawrence River. Fisheries for which no data on by-catch levels were available were identified. The workshop agreed that the best estimates of by-catch by the U.S. Gulf of Maine sink gillnet fishery in 1990 and 1991 are approximately 2,400 (95 percent CI 1,600 to 3,500) and 1,700 (95 percent CI 1,100 to 2,500), respectively. The workshop noted, however, that there is an unknown amount of by-catch of porpoise from this population by other fisheries in the U.S. and Canada. Estimates of by-catch of harbor porpoise from the St. Lawrence population were reviewed, but confidence intervals were not estimated and potentially large biases were identified by the workshop. No useful estimate of total by-catch from the Newfoundland population was available.

The workshop reviewed information on the ecological role of harbor porpoise throughout the region, and concluded that the species has been able to maintain itself as a functioning element of its ecosystem.

The workshop drew conclusions about the status of harbor porpoise populations in eastern North America based on information of the known removals as measured relative to estimated population size, adequacy of regulatory structures, and the ecological role of the species. The by-catch by the U.S. Gulf of Maine sink gillnet fishery in 1990 and 1991 was estimated to have been 5 percent (95 percent CI 2.6 to 10.1 percent) and 4 percent (95 percent CI 1.8 percent to 7.7 percent) of the estimated abundance, respectively. These rates did not account for by-catch in other fisheries known to kill harbor porpoise, and are high relative to the recommendations of the Scientific Committee of the International Whaling Commission. Regulatory structures existing in the two countries were identified that appear to have the potential for managing the by-catch of harbor porpoise, but workshop participants noted that at present these structures were insufficient in that specific controls of by-catch are currently not in place. The reported levels of by-catch from both the Newfoundland and St. Lawrence populations could not be evaluated relative to likely population size, and the data on by-catch had several identified weaknesses.

The workshop recommended that the level of by-catch of harbor porpoise from the Gulf of Maine and Bay of Fundy population be reduced, and that for the St. Lawrence and Newfoundland populations surveys of abundance be initiated and estimates of the by-catch be improved. Other research needs were identified.

ABSTRACT

Information relative to the status of harbor porpoise *(Phocoena phocoena)* in eastern North America was reviewed by U.S. and Canadian scientists from that region, with assistance from experts in cetacean population dynamics, population genetics, and abundance estimation from other areas. New data on molecular genetics, levels of by-catch, and abundance were reviewed, along with previously available information. A working hypothesis of three populations was adopted (Gulf of Maine-Bay of Fundy, St. Lawrence, and Newfoundland), although an alternative hypothesis of one population was also considered consistent with the available data. By-catch estimates for the U.S. Gulf of Maine sink gillnet fishery were accepted (2,400, with 95% CI 1,600 to 3,500 for 1990, and 1,700, with 95% CI of 1,100 to 2,500 for 1991). Estimates for other fisheries were either not available or suffered potentially large uncertainties. An abundance estimate for the Gulf of Maine-Bay of Fundy population was accepted (45,000, with a 95% CI 19,000 to 80,000). Useful estimates of abundance for the other populations do not exist.

For the Gulf of Maine-Bay of Fundy population, by-catch by the U.S. Gulf of Maine sink gillnet fishery constituted 5% of the estimated population size in 1990 (95% CI 2.6% to 10.1%) and 4% in 1991 (1.8% to 7.7%). These rates are high relative to the advice of the Scientific Committee of the International Whaling Commission, especially given that there are unknown levels of by-catch from this population from other U.S. and Canadian fisheries. For the St. Lawrence and Newfoundland populations a similar evaluation of the likely biological significance of the by-catch cannot be made. It was recommended that by-catch from the Gulf of Maine-Bay of Fundy population be reduced, and that new data on by-catch and abundance be collected for the St. Lawrence and the Newfoundland populations.

INTRODUCTION

Harbor porpoise (*Phocoena phocoena*) occur in eastern North America from North Carolina north to Labrador. Extensive seasonal movements are known or suspected, at least in the southern portion of the range, and the degree of genetic separation over the entire range is poorly known. Direct harvest of this species is known to have occurred in the past. The species is taken as by-catch in fishing operations throughout this region. Other human activities may also have indirect effects on the species. For example, the abundance of prey such as herring has fluctuated historically, in part due to fishing activities.

Several significant scientific studies of this species have been reported previously, especially in the Bay of Fundy and in the northern Gulf of Maine. The basic life history has been established, and the distribution and some seasonal changes in that distribution have been reported.

Increasing concern about the status of this species in eastern North American has been reflected in Canada and the U.S. In Canada the species has been listed as a threatened species by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). In the U.S. the Marine Mammal Protection Act was amended in 1988 to attempt to obtain information on the by-catch of all marine mammals. Concerns about harbor porpoise in the Gulf of Maine have been expressed in a formal petition under the Endangered Species Act for classification as a threatened species (NMFS 1991). The Scientific Committee of the International Whaling Commission conducted a general review of the status of this species in 1990 and 1991, where it was recommended that by-catch be reduced in the western North Atlantic.

Beginning in the late 1980s, additional research on the biology and threats to this species was begun in many areas, including the Black Sea, the North Sea, the eastern and western North Atlantic, and the eastern North Pacific. New results from research conducted on harbor porpoise in eastern North America have become available, and these have been sufficient to allow the status of the species in this region to be evaluated. To complete such a review, a workshop was held May 5-8, 1992, at the Northeast Fisheries Science Center in Woods Hole, Massachusetts, U.S.A.

The goals of the workshop were to (1) review available data and analyses relevant to determining the status of the harbor porpoise in eastern North America, and (2) identify research needs for developing an improved understanding of status of the species in this region. The results are reported here, and represent the best judgement of scientists involved (Appendix 1), based on the scientific information available at that time. Some 33 working papers were submitted to the workshop and are referred to in this report as WP ## (Appendix 2).

SEASONAL DISTRIBUTION

GULF OF MAINE/BAY OF FUNDY

Greatest densities of harbor porpoise appear in the lower Bay of Fundy (around Grand Manan Island) in mid-August. Stranding records and sighting data in the Gulf of Maine/Bay of Fundy suggest seasonal movements. Harbor porpoise arrive in the Bay of Fundy in July and are found in small groups. Larger aggregations (20 to 40 animals) appear in the lower Bay of Fundy in October and leave soon thereafter. Strandings in these areas are rare in winter months, although there are sporadic records. Gaskin (WP 28) reported animals caught in herring weirs in March, Kraus reported seeing animals in December, and Wang suggested that Gaskin also had January or February sightings. These sightings are of a few, scattered individuals and it was suggested that they may be juveniles. By-catch is recorded on Jeffreys Ledge in October/November (WP 12) and some animals are taken further east in area 515 (WP 12). Animals have also been recorded on Jeffreys Ledge in January of 1991 (WP 12). Late winter and early spring occurrences are reported in Cape Cod Bay and Massachusetts Bay; for example, in March 1991, a large aggregation (100+) animals was seen off Provincetown, MA (F. Wenzel, personal communication) and animals are currently (April 1992) reported in both areas (WP 12). Porpoise have also been seen south of Cape Cod. In January 1991, a ship survey near Nantucket Shoals saw 24 animals, and sightings data from 1979-80 indicates the presence of animals in the Great South Channel in March/April (CeTAP 1982).

Although no dedicated sighting efforts are made south of Cape Cod in winter months, stranding and by-catch data suggest strongly that animals migrate south of Cape Cod in the winter. During winter months there are stranding records for harbor porpoise as far south as Florida (WP 4). There are no records for South Carolina or Georgia and the two Florida strandings are possibly outliers and hence not true indicators of the normal southern extent of the harbor porpoise's range. A January 1992 sighting survey from Cape Hatteras to Miami from the 30 fathom line out to the Gulf Stream recorded no harbor porpoise (Nicolas, personal communication). Thus, stranding data suggest that North Carolina represents the southern extent of the range and they may be confined to water less than 30 fathoms in this area. From November to April, by-catch is recorded from shad and demersal fish fisheries off New Jersey and in Chesapeake Bay. Read noted that there were winter takes, determined by stranded animals with net marks, in New Jersey, Delaware, Virginia, and North Carolina. Payne reported 6 animals were found stranded on Virginia beaches and 14 animals on New Jersey beaches in the spring of 1991 (some with indications of entanglement). North Carolina has the second highest number of recorded strandings (after Massachusetts) with the largest number of animals stranding in March/April; these are episodic, with the cold winters of 1976/77 and 1986/87 having 88% of the total strandings. No strandings have been reported in this area since 1989 (D. Wiley, personal communication, International Wildlife Coalition, Falmouth, Massachusetts). Wiley also noted that there are identification problems with harbor porpoise south of Cape Cod and so stranding data may under-represent the true number of strandings.

No strandings data exist for harbor porpoise south of Cape Cod in summer months. No sightings of harbor porpoise were made after mid-June from whale watching vessels operating in Massachusetts Bay (Kraus, *et al.* 1983). Sightings south of 43°N in July and August are rare. This strongly suggests a seasonal north/south movement of harbor porpoise along the Northeastern seaboard.

NOVA SCOTIA

There is a paucity of information concerning the distribution of harbor porpoise around eastern Nova Scotia. Animals have been recorded from the southern tip of Nova Scotia to Digby Gut (north of Yarmouth) in August, and on Brown's Bank in July, August, September and a few in October. Animals have been recorded north of Halifax to Cape Breton Island in April and early May. B. Beck, Canadian Department of Fisheries and Oceans, as reported by Palka, has seen up to seven harbor porpoise caught in one mackerel set net and he has also seen large groups of harbor porpoise (10 to 50 animals) feeding on the mackerel. Mackerel are known to move north along the coast of Nova Scotia to the tip of Cape Breton and into the Gulf of St. Lawrence in May-June, and cetaceans are reported to follow the mackerel (M.

Castanguay, personal communication to Kingsley). M. Kingsley reported his plan to travel to Cape Breton at the end of May to follow up on this information. B. Beck suggested that harbor porpoise are following the fish north along the coast of Nova Scotia as animals are caught in set nets along the central coast earlier than they are caught along the northern coast. He has also seen stranded harbor porpoise in January/February off Sable Island.

There are only a few sightings of harbor porpoise along the southeastern coast of Nova Scotia from Browns Bank to Halifax. It is unclear whether this is a true gap in their distribution or simply a result of low sighting effort, no stranding information and/or low fishing effort in this area.

NEWFOUNDLAND

According to Gaskin (WP 28) harbor porpoise are distributed seasonally in the coastal shelf waters of Labrador and Newfoundland. Stenson (WP 34) reported winter and spring occurrence off the slopes of the Grand Banks past 1,000 m and on the shelf. There are also winter sightings reported off northeast Newfoundland (Lien, personal communication to Stenson). There are two summer reports from the Labrador Sea (WP 34) and summer records as far north as Baffin Island (70°N). Porpoise are also caught in May-August (WP 34) in inshore waters off Newfoundland. There is little information for the west coast of Newfoundland, although there are sporadic reports of animals being seen there.

GULF OF ST. LAWRENCE

We know little about the distribution and movement of harbor porpoise within the Gulf. In summer they are widely distributed at least as far upstream as the mouth of the Saguenay River, but distribution appears patchy. Higher densities are reported along the north shore (M. Kingsley reported that this is confirmed by observations by R. Sears of 20 to 500 animals from June to October) and possibly along the east end of the Gaspé Peninsula. Ice starts to form in December, but porpoise can probably remain in the area for some time after this as the ice cover is seldom, complete particularly along the north shore. Lien (personal communication to Stenson) reports having seen harbor porpoise in pack ice. However, the Gulf is probably unsuitable for harbor porpoise during (some) periods of each winter.

There is little quantitative information on the population's distribution (*i.e.* density) except during the summer in the Gulf of Maine. Gaps in our knowledge of harbor porpoise distribution include southeastern Nova Scotia and portions of the Gulf of St. Lawrence. This is most commonly a result of lack of sighting data, stranding information, and/or observer effort in these areas. The distribution during winter months is also not well documented. It is unclear what route the Gulf of Maine and Bay of Fundy animals are taking as they move south in the fall and winter, although it appears that we cannot rule out an offshore route, perhaps down the Scotian shelf and out to the margin of Georges Bank. In Canadian waters it is also unclear where Gulf of St. Lawrence and Newfoundland animals go during winter months.

POPULATION STRUCTURE

Based on coincident summer distribution patterns, Gaskin (1984) suggested that there were four, more or less, separate groups of harbor porpoise in the western North Atlantic, which he referred to as sub-populations. These were (1) western Greenland, (2) eastern Newfoundland, (3) Gulf of St. Lawrence, and (4) the Bay of Fundy, Gulf of Maine, and southwestern Scotian shelf. This division was based on assumptions that porpoise were confined largely to continental shelf areas, and hence were not able to regularly move between these areas.

Results newly available from comparisons of the mitochondrial genome of samples of harbor porpoise from different areas were presented. One method, presented by Rosel (WP 3), was the sequencing of a relatively rapidly mutating portion of the mitochondrial genome; the other, by Wang (WP 2), was the analysis of restriction fragment length polymorphism (RFLP) of the entire mitochondrial genome. The samples for these studies included animals in the eastern Pacific, the Black Sea, and the eastern north Atlantic, as well as the several putative populations in the western north Atlantic. Genetic distinctions at the oceanic level and between the two coasts of the same ocean, were in general clear, but neither method indicates genetic differences between the three groups of animals suggested by Gaskin. This was true even for females, for which, under certain social structures (*e.g.* matriarchally-driven philopatry as found in belugas, Helbig *et al.* 1990), mtDNA analysis is more apt to discriminate populations than it is for males. More detailed mathematical analyses of the RFLP data are proposed, but the

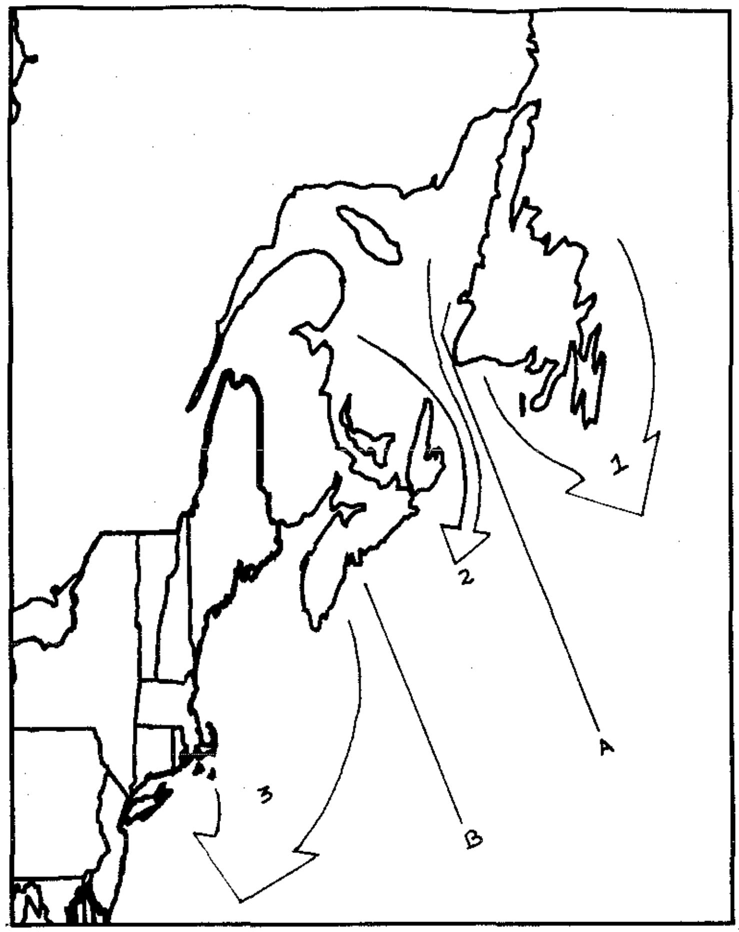

Figure 1. Hypothetical structure of some of the North Atlantic harbor porpoise population (Greenland ignored). Using summer breeding information, three subpopulations were proposed: (1) Newfoundland, (2) Gulf of St. Lawrence, (3) Gulf of Maine/Bay of Fundy. The arrows indicate a likely, though not the only, direction animals travel from their respective breeding grounds to possible wintering grounds.

prospects for different results are unclear. Interestingly, the RFLP analysis of the mitochondrial genome indicated high genetic diversity in comparison with other mammals, terrestrial as well as marine, probably indicating that populations are not, and have not recently been, depleted.

It was noted that a very preliminary study using protein electrophoresis (Read, personal communication) failed to differentiate *Phocoena phocoena* from *P. spinnipenis*. Although L. Andersen (WP 26) was noted to have reported preliminary electrophoresis results indicating protein differences between Greenland and St. Lawrence populations, the workshop did not know of any subsequent confirmation of this report.

Genetic information obtained thus far does not support that the three hypothesized populations are reproductively isolated. However, the inability to detect genetic differences among these groups to date does not rule out the possibility that they are, in fact, distinct populations. Recent separation or very low levels of mixing would hamper attempts to detect genetic differences. Future studies employing larger sample sizes for the three eastern North American populations for MtDNA studies (WP 3) and other molecular techniques, including random amplified polymorphic DNAs (RAPD) and characterization of the major histocompatibility complex, may reveal genetic differences among these populations.

The observation was made that distinctions demonstrated by genetic analyses would certainly justify definition of management stocks, but that in general, groups could be sufficiently distinct to justify management as separate stocks, even though there exists high enough rates of exchange to eliminate genetic differences.

On the basis of recent information that animals in the three areas breed simultaneously, the workshop suggested that Gaskin's proposed population structure be used as a working hypothesis. It is unknown, however, if animals from the three groups mix at other times of the year. One possible pattern of movement of animals in these three areas is shown in Figure 1.

FUTURE RESEARCH

Research that might be undertaken to test the population hypothesis adopted includes:

- **Differences in the readability of teeth**
  The workshop suggested attempting to quantify the recently reported observation of systematic differences in the readability of teeth from animals in the hypothesized three stocks.

- **Pollutant concentration and ratio information**
  The workshop noted that contaminant comparisons of both organochlorines and heavy metals are under way at the University of Guelph, and that analyses of polycyclic aromatics and other hydrocarbons have begun at the Northwest Atlantic Fishery Center in St. Johns, Newfoundland.

- **Skull morphometric analyses**
  Although this approach has been tried (Yurick and Gaskin 1987) and did not produce any clear discrimination because intra-population variability was high, it may be worth trying again with larger sample sizes and using new image processing techniques.

- **Parasite load, community composition, and genetics**
  The workshop suggested that these approaches may be useful, and noted that some data are being collected in Canada.

- **Tagging**
  The workshop noted that conventional tagging was unlikely to be successful, as the low recovery rate would mean that many tags would have to be applied, and it would be expensive to apply large numbers of recovery tags in the wintering areas, even if the tag retention problem was to be solved. Satellite tagging is more promising, particularly now that satellite tags are small enough to be carried by harbor porpoise. However, problems of capturing animals at sea and retention of tags must be overcome.

- **Timing of reproduction**
  The workshop suggested that more precise information on reproductive timing and length of the seasons of parturition and breeding in each summering area would be useful.

- **Stable isotopes of nitrogen and carbon**
  The workshop suggested that the analysis of stable isotope ratio in tissues that have low rates of turnover, such as teeth, would indicate diet over long periods. This would be a potential indicator of long-term differences in migratory patterns, although it was noted that interpretation may be a possible problem.

- **Molecular genetics data**
  The workshop suggested that other methods of analysis of genetic data, for example Slattin and Maddison (1990) and Neigel, *et al.* (1991), may be useful for estimating migration rates or dispersal distances from birthing site to breeding site. Other molecular genetic measurements that may prove useful include the major histocompatibility complex in nuclear DNA and polymerase chain reaction randomly amplified polymorphic DNA techniques.

- **Determine winter grounds**
  One possibility is that the animals winter in separate grounds, for example the regions from Jeffreys Ledge to Cape Hatteras for the Gulf of Maine and Bay of Fundy population, the northern part of the east coast of the Nova Scotia shelf and Sable Island for the St. Lawrence population, and the shelf break of Grand Banks for the Newfoundland population (Figure 1). Suggestions for testing the hypothesis of such discrete wintering groups included winter distribution surveys, particularly on the Scotian shelf. A winter (January/February) survey would be predicted to show porpoise (from the St. Lawrence group) present in the northerly part of the Scotian shelf, and a possible gap in the distribution somewhere in the southern part of the shelf. In connection particularly with the management problem of identifying which summering group or groups are being impacted by winter by-catches in the southern Gulf of Maine, such a result might support the hypothesis that the St. Lawrence and Newfoundland summer groups were unaffected. It was noted that before conducting such a survey, winter by-catch and survey sighting data should be sought out and assembled to form the best possible picture of winter distribution.

- In connection with this, it was noted that a description of the average seasonal movements of the 8° to 10°C surface temperature band of water may be useful as a possible indicator of suitable habitat. Further, a description of the amount and distribution of fishing effort and harbor porpoise by-catch (including zero by-catch) in groundfish gill-net fisheries, and other fisheries using gear known to take harbor porpoise when present, would be valuable in improving our understanding of seasonal movements and population structure.

VITAL RATES

Vital rates (*i.e.*, rates of survival, reproduction, development,growth, *etc.*) are the basis on which demographic models are constructed. The vital rates working group began by noting that there are no data available that would permit the estimation of the *actual* rate of increase of any specific harbor porpoise population.[1] Instead, the discussion focused on the estimation of *potential* rates of increase, ways to estimate these rates, and factors influencing them. Potential rates of increase of harbor porpoise populations have been estimated by Barlow and Boveng (1991) and Woodley and Read (1991, WP 6), and their results used by the IWC (WP 25). While their analyses differ in some details, they use similar methods and reach similar conclusions.

The first step was to compare model structures. A useful framework for discussing analyses of this sort is provided by matrix population models and the corresponding life cycle graphs (Caswell 1989a). This framework eliminates the difficulties associated with choosing a correct characteristic equation for discrete life tables, permits easy comparison of various model structures (see later discussion), has a well-developed sensitivity analysis, and can be extended to include stochastic environmental effects (Tuljapurkar 1990).

Four alternative models were examined: (1) a complete age-structured matrix model including yearly age classes; (2) an aggregated model including a single adult stage with assumed age-independent mortality; (3) a matrix model that partitioned the population into two classes: juveniles and adults; (4) a matrix model that partitioned the population into three classes: juveniles, active adult breeders, and inactive adult breeders.

The complete age-structured model (model (1); see Woodley and Read 1991) was considered to be most applicable to the assessment of direct human-induced mortality on the harbor porpoise population, partly because Barlow and Boveng (1991) and Woodley and Read (1991) reported being unable to produce models with age-independent survival probabilities and observed maximum lifespans that would permit positive population growth. In addition, models that lump age classes cannot examine the effects of age-specific mortality factors. However, the determination of the input parameters, in particular age-specific mortalities, were identified as major uncertainties that should be determined more precisely with further research.

The workshop expressed concern about relying on point estimates of potential rates of increase, without an indication of the ranges of uncertainty associated with those estimates. A procedure for quantifying the uncertainty associated with the intrinsic growth rate (or any other demographic parameter) was outlined. It would begin with estimates of the parameters (*e.g.*, age-specific survival and reproduction) for a given model structure, with ranges of uncertainty associated with each parameter. A Monte Carlo estimation procedure, selecting parameters randomly from these ranges (using uniform distributions in the absence of more detailed information), would yield a distribution of values of the population growth rate. Recently developed methods of sensitivity analysis (Caswell 1989b, , Brault and Caswell 1992) would then be used to decompose the variance in the estimated growth rate into components arising from variance in each of the parameters, thus pinpointing the most important parameters. Improving the accuracy of estimating those parameters would be a high research priority.

Demographic models require estimates of reproductive rates and survival rates. The workshop concluded that pregnancy rates and age at maturity are well-estimated from observations on specimens captured in commercial fisheries (Read 1990, WP 33). Pregnancy rates are not equivalent to reproductive rates, since they ignore fetal loss rates and (in a birth-pulse population with a pre-breeding census) first-year mortality rates, but they provide an upper bound on reproductive rates, which is suitable for estimating potential rates of increase.

Survival rates, in contrast, are essentially unknown in harbor porpoise. The methods for estimating such rates require either longitudinal studies of identified individuals (impossible for harbor porpoise) or unbiased estimates of the age distribution with assumptions about stability and stationarity of the population. Age distribution estimates from by-catch or stranding data appear to be biased toward younger animals (WP

[1] Data on reproduction are fairly good, but data on survival are nonexistent

25). Thus, although the shape of the age-specific survivorship curve is crucial to developing demographic models, in this case it will have to be inferred from very fragmentary information.

Barlow and Boveng (1991) and Woodley and Read (1991) used the method of *model life tables* as a solution to this problem. This approach replaces the unknown survivorship function of the species in question with an appropriately rescaled function from some more well studied species (or population). The species involved need not be taxonomically similar (Barlow and Boveng used monkeys, humans and fur seals; Woodley and Read used the Himalayan thar), but should have similar life histories. Alternatively, model life tables can be constructed from mathematical parameterizations of the survivorship function (*e.g.*, Siler 1979, Coale and Demeny 1966).

Given an observed maximum lifespan (estimates range from 12 to 15 years), there are a set of survivorship functions ranging from an age-independent (exponential) form (rejected as biologically implausible on the basis of Barlow and Boveng's and Woodley and Read's results) to a rectangular form in which all individuals live to the maximum age and then die. The procedure for estimating a plausible range of rates of increase requires a way to sample curves falling into a "reasonable" range of this space. Two approaches were suggested.

The first approach (analog approach) would estimate the shape of the survival curve by comparison with appropriate data from other mammalian populations. The second approach (interpolation approach) would use another life history parameter, such as life expectancy at birth, to provide a point between known values of the survival curve at age 0 and at the presumed maximum age for interpolation.

The workshop concluded that the two approaches would be complementary, and key features were identified for both. The analog approach requires an appropriate choice of species. Several *ad hoc* criteria were suggested for selecting data: the species should be an annual breeder with a small litter size (ideally, a species that does not twin) and the proportion of the lifetime spent as a reproductively active individual should be similar. The interpolation approach will be most useful if the ancillary demographic parameter is estimable from the limited age distribution data on the harbor porpoise (keeping in mind the problems with age structure stationarity and stability). However, the two primary sources of age distribution data, by-catch and stranding records, were considered to be potentially biased due to age-specific selectivity associated with each. Nonetheless, the workshop concluded that the pursuit of both theoretical approaches would be most informative.

As mentioned earlier, the workshop felt that data on age-specific maturation, pregnancy rates and longevity were well-determined, although further research on the validity of age-determination methods would be desirable. Several other issues as appropriate for inclusion in future research were identified.

- Population spatial structure may have important effects on potential population growth rate. Uncertainty associated with the population structure was expected to be addressed by the workshop on stock structure; metapopulation models (Gilpin and Hanski 1991) may be appropriate depending on what is learned about the extent of subdivision of the population.

- Demographic analyses should not be limited to consideration of population growth rate. The utility of other indices, including particularly sensitivity and elasticity coefficients, should be examined. These coefficients would give information on the impact of (human-induced and other) perturbations of the life cycle, and may be less affected than estimates of growth rate by uncertainties in the data.

- Analyses should be extended to include stochastic models for effects of environmental variation (Tuljapurkar 1990). It is known in general that environmental variability can have important effects on the persistence of populations; it is completely unknown whether the harbor porpoise life history is sensitive to these effects or not. Because recently weaned yearlings make up a high proportion of stranded animals, and because stranding frequencies vary from year to year, it was suggested that inter-annual variability in yearling survival may be an important source of stochastic variability.

- Models should eventually be extended to incorporate (possibly age-specific) mortalities due to by-catch and other human intervention. In addition to by-catch, the possible effects of a reduction in the densities of harbor porpoise predators (sharks) due to fishing pressure, and possible changes in food supply due to exploitation of herring, capelin and mackerel (see Ecological Relationships working group report) was discussed.

In summary, the vital rates for the harbor porpoise are largely unknown and there is little prospect of obtaining good estimates of *actual* rates of population increase in the foreseeable future. The workshop was unable to provide any new estimates of these rates. There are, however, good possibilities to use the available data to estimate *potential* population growth rates and to quantify the extent of uncertainty in those estimates. This would be a step beyond the results of the IWC (WP 25), which remain the best summary of these calculations to data, but which were based on point estimates of potential rates of increase. Research to achieve these objectives would be relatively inexpensive, and could contribute to the assessment of the impact of bycatch and other sources of mortality.

POPULATION SIZES

Estimates of harbor porpoise abundance are available for the Gulf of Maine and Bay of Fundy; no estimates are available for other regions of the Northwest Atlantic. The most comprehensive survey of the Gulf of Maine and Bay of Fundy was conducted by NMFS in July and August 1991 (WP 16); the working group reviewed the design and data analysis of this survey in detail.

SURVEY DESIGN

The NMFS survey (WP 16) covered the known summer range of harbor porpoises in the Gulf of Maine and Bay of Fundy. The area was divided into three strata on the basis of previous knowledge of porpoise density (high, intermediate and low porpoise density areas) and an additional inshore area in which the main survey vessel was unable to navigate. This inshore area was surveyed by a smaller vessel during the same time period (WP 17). The high, intermediate, and low density strata were further divided into blocks, each of which could be covered during a single survey day. Blocks were selected at random for each day, with the constraint that the vessel could travel to that block from its position on the previous day during the night. Within each block, each day's survey starting point was selected at random and the pattern of survey tracklines was selected to avoid following possible environmental gradients.

FIELD METHODS

On the main survey vessel, two independent teams of four observers were used to obtain an estimate of g(0), the probability of detecting a porpoise group surfacing on the trackline (WP 22). The four-person observer teams rotated through three observer positions and a rest station. Each team searched the entire area ahead and to the side of the vessel. Each observer recorded his/her own data, which may have resulted in a small number of missed sightings, particularly in the high density stratum. Some group members also expressed concern over the demanding observation schedule and consequent potential for observer fatigue. Observers were trained in distance estimation techniques at the beginning of the survey and at irregular intervals thereafter. The group noted the potential for introducing bias in abundance estimation if bias exists in distance estimation, and encouraged the development and use of more objective methods of estimating distance.

LINE TRANSECT ANALYSES

Line transect methods were used to estimate harbor porpoise density. The group reviewed in detail the various components of this methodology, paying particular attention to the possible introduction of bias and potential means of reducing the magnitude of variance associated with the density point estimate. Sighting rates decreased markedly from Beaufort sea state 1 to 2 (WP 19). The consequences of this effect on abundance estimation were investigated in two ways: by using a bivariate line transect model and by stratification by sea state. Neither technique demonstrated an appreciable effect of sea state on estimates of abundance. Surprisingly, given the magnitude of the effect of Beaufort sea state on porpoise sighting rates, this effect was not significant when included as a covariate in variety of line transect models. Members of the working group expressed concern that the bivariate detection functions used in covariate analysis might be inappropriate for assessing the effect of a nonlinear, ranked variable, such as sea state, on sighting detection. Further exploration of the effect of sighting conditions on abundance estimation is warranted. If, as might be expected, a larger number of animals are missed by observers when conditions are poor, stratification by sea state in estimating g(0) (discussed below) should be explored as a means of eliminating potential bias and reducing variance.

The working group stressed that in estimating the probability of detecting a porpoise group surfacing on the trackline, g(0), it is useful to think in terms of two classes of porpoise groups: 1) groups that surface and are available to be seen and 2) groups that never surface within the sighting range of observers. It was emphasized that methods used during last year's survey (WP 22) only address the first of these. Given the dive times of harbor porpoise (Read and Gaskin 1985) and the survey speeds used, some groups could remain submerged during the entire period that they were potentially visible to the observers.

Estimation of g(0) required determination of the number of duplicate sightings made by two observer teams searching independently (WP 22).[2] The use of two observer teams allowed abundance to be estimated in four ways. The estimate derived from the "direct" method was slightly lower than the corresponding three estimates from the "product integral" method (Butterworth and Borchers 1988), although the difference was not statistically significant. The working group felt that the estimate of g(0) from the direct method, approximately 0.70 (CV 10.5%), is superior to the other methods. Further work is required to objectively estimate the probability of correctly determining duplicates, rather than using subjective matching and weighting techniques. An alternative and simpler approach is to estimate g(0) using only definite duplicate sightings and to compare this result with the estimate produced using both definite and all possible duplicate sightings.

Significant bias can be introduced into density estimates if animals react to a survey vessel (Polacheck and Thorpe 1990, WP 21). There was no indication from the distribution of perpendicular sighting distances that harbor porpoises were avoiding the survey vessel. The distributions of observed swimming directions indicated that harbor porpoise were reacting to the vessel prior to being seen (WP 20). However, it was not possible to conclude that this introduced a bias. Attempts to detect reaction of porpoises to the approaching vessel by monitoring animal movements with 25 power binoculars were inconclusive. The group concluded that, given available data, it was impossible to assess the effect of animal movement in reaction to the vessel on abundance estimates.

The confidence limit around the abundance estimate was calculated in two ways: the lognormal and bootstrap methods. The lognormal is easier to calculate and serves as a useful comparison to the bootstrap estimates using the percentile method, which may be biased (Efron 1982). Group members recommended using a bootstrap estimate with a larger number of repetitions (1,000) to define confidence limits. The resampling unit used in bootstrap calculations was survey day. Because of the extremely low number of days in some strata, other sampling units (*e.g.* legs or transects) should be used. The majority of the variance associated with the point estimate was caused by variation in encounter rate, and the group discussed several possible stratification schemes that might be used to reduce this variation, that should be investigated. The analyses may have overestimated this component of variance because bootstrap replicates are treated as if they were true replicates when in fact they are not (Buckland, *et al.*, in press). The procedures for correctly estimating sampling variation discussed in that paper should be incorporated in future analyses of the 1991 survey data. However, considerable spatial variation in encounter rate is a common and unavoidable phenomenon in harbor porpoise surveys, and a high variance can be expected.

Individual observer performance was not assessed directly in the analysis of survey results, although observers were divided between the two teams on the basis of prior survey experience and a preliminary assessment of individual sighting rates. The group encouraged quantitative analysis of the effect of observer heterogeneity in sighting rate and distance estimation (both among individuals and within particular observers over time) on abundance estimation.

It was pointed out that estimates of the parameters of the sighting process were quite similar among the geographic strata that were used. Due to the similarity of parameter estimates across strata, it might be possible to pool these data to achieve a more parsimonious result that would reduce the variance associated with the point estimate.

The current analysis (WP 23) assumes that detection is not influenced by group size. Palka described the results of tests to determine (i) if large groups of harbor porpoise are more likely to be seen at a distance, or (ii) if variance associated with estimation of group size changes with distance. Tests of these assumptions should be reported. Simple methods, such as the elimination of group size estimates collected at long distances from estimation of mean values, may assist in eliminating potential bias. Alternative definitions of a porpoise group were discussed and should be further explored prior to future surveys.

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2 Duplicate sightings were those groups of porpoises that were seen by both teams.

RELATIVE INSHORE DENSITY

As mentioned earlier, the density in inshore bay waters of Maine could not be surveyed with the primary vessel due to its deep draft; therefore, relative density was estimated in this area, and in a 5 nmi offshore strip using a smaller vessel. The results of this survey made by the secondary research vessel indicated no significant differences in either encounter rate or group size between the inshore stratum and the adjacent offshore waters of the intermediate density stratum (WP 17). It was noted that the lack of significance could be due to a lack of statistical power rather than a lack of difference. The group suggested that, rather than assuming the actual density in the inshore area is exactly equal to that of the intermediate stratum, a better approach would be to use the measured ratio of porpoises seen in the two areas to estimate the density in the inshore area. The effect of land masses on the probability of detection was raised as a possible problem in the inshore area, where islands and the mainland shoreline often encroach into the effective survey strip.

The workshop agreed that the Gulf of Maine and Bay of Fundy survey provided reliable density estimates using the best available survey techniques. The abundance estimate produced from this survey, 45,000 (95% CI: 19,000 to 80,000), is unlikely to change substantially with further analysis. However, it was noted that this estimate is likely to be biased, and that most identified sources of potential bias would result in it being an underestimate of porpoise abundance.

RESEARCH RECOMMENDATIONS

The planned replication of the 1991 ship survey in 1992 is recommended strongly. The group made several recommendations regarding future harbor porpoise surveys, and particularly the survey planned for the summer of 1992. Survey results from 1991 should be used to fine tune the delineation of density strata. The new survey design should incorporate information on the effects of any environmental variable, such as depth, that can be shown to influence porpoise distribution, into the stratification scheme. The group agreed that disproportionate allocation of survey effort into high density areas might be useful to reduce the variance estimate. The group also agreed that, given limited resources, a repeat of the survey of inshore waters was unnecessary. Effort should be directed in better defining the limits of the summer harbor porpoise distribution along the eastern shore of Nova Scotia and the coast of southern Maine. The use of experienced observers was encouraged, as was incorporation of rotation schedules that reduced the potential for observer fatigue. The group concluded that, if the use of binoculars in high density areas was impractical, they should not be used in any stratum to avoid the inclusion of a potentially confounding observer effect.

There is a need to estimate the fraction of harbor porpoise missed by ship surveys due to the porpoise being submerged. Possible approaches to this problem include: 1) measuring dive times of porpoise and constructing a mathematical model of the probability that a diving porpoise on a trackline would surface within the sighting range of a vessel moving at 10 kts; 2) developing acoustic methods (sonar) for detecting submerged porpoise as the survey vessel is passing; and 3) measuring the actual fraction of all porpoise missed by tracking porpoise groups from a cliff or from a helicopter as the survey vessel passes by.

TRENDS IN ABUNDANCE

There is little quantitative information related to trends in abundance of North Atlantic harbor porpoise. There is no available information on trends in abundance or by-catch from the St. Lawrence and Newfoundland stocks. There are six sources of information pertaining to trends in abundance of the Gulf of Maine stock, reported in WP8 and WP28. One problem with all of these studies of trends is that the timing, magnitude, and spatial distribution of the peak abundance changes between years. This makes it very difficult to detect trends in abundance over time. Methods to analyze "noisy" data are needed. The general conclusion made by the committee was that, at the present time, there is no useful information on trends in abundance of harbor porpoise in the Northwest Atlantic.

Previous abundance estimates are not comparable because of differences in survey area, field methods, and analytical techniques. Thus, although the recent estimate is considerably larger than previous estimates, it is not possible to draw inferences regarding temporal trends in abundance.

The workshop noted that there is a need to begin a program of monitoring harbor porpoise abundance through time. Continued ship surveys could be used for this, but would be expensive. A less expensive alternative would be to establish a program based on detecting changes in relative abundance. For example, Barlow described the monitoring program based on aerial surveys in central California. Using this relatively inexpensive method, it is expected to require 10 years to detect a 5 to 10% annual change (Forney, *et al.* 1991). In the Gulf of Maine and Bay of Fundy, sighting conditions and harbor porpoise densities are different from those in central California. Several options for design of such surveys, and in determining their optimal frequency need to be considered.

ECOLOGICAL RELATIONSHIPS

PREY

Significant changes in some life history parameters (female age of sexual maturity, juvenile growth) of Bay of Fundy harbor porpoise were observed between the sampling years of 1969-1973 and 1981-1986 (Read and Gaskin 1988). Since these changes occurred over a fairly short time period (about 13 years) and appeared after the beginning of the Bay of Fundy gillnet fishery for groundfish, it was suggested that these changes might be a response to a change in abundance of harbor porpoise caused by this fishery. These authors also suggested an alternate hypothesis that changes in harbor porpoise life history reflect changes in the abundance, distribution or energy density of their major prey species.

Atlantic herring *(Clupea harengus)* is the primary prey species for porpoise in the Bay of Fundy during the summer, with some important contributions from silver hake *(Merluccius bilinearis)* and Atlantic cod *(Gadus morhua)* (Recchia and Read 1989). In the Gulf of St. Lawrence, capelin *(Mallotus villosus)* is the primary species found in the stomachs of porpoise, as reported by Kingsley. Capelin appear to comprise at least part of the Newfoundland porpoise diet, reported to the groups by Stenson. The stomach contents of animals collected from gillnet by-catch may not be representative, since Smith and Gaskin (1974), using a different collection method, found that mackerel was an important prey species to at least some of the Bay of Fundy porpoise.

The energetics involved in capturing other prey species such as hake may help in understanding the movement and reproductive behavior of porpoise. The diet composition of porpoise during the winter (or during transition periods between summering and wintering grounds) is not well known. Stomachs from animals caught in the Gulf of Maine during the winter are available for examination. Suggestions were also made to examine the possibility of food limitations during the winter season when energetic stress may be greater.

The abundance of herring appears to be increasing. The distribution of herring in the Gulf of Maine and Bay of Fundy region appears to have changed as well. Assessment information supports these observations. Radio-tracking data (Read and Gaskin 1985) indicate that harbor porpoise forage primarily during daylight hours when herring (and hake) gather in dense schools in deep water. Harbor porpoise are inactive at night. During this period, their prey species are near the surface but in diffuse aggregations. Substantially more information about harbor porpoise prey species, such as daily and seasonal distribution, density, and abundance is needed.

The harbor porpoise is the smallest cold-water cetacean species and is capable of reproducing annually; these traits are energetically expensive and may dictate that the porpoise follow their prey (WP 7). Some evidence exists to support this view. Payne noted that herring and porpoise concentrations have increased in the inshore waters of the Gulf of Maine. The herring stock of Nantucket Shoals has increased and so have the numbers of porpoise in this region. Platt and Nettleship (1977) observed that the highest level of porpoise by-catch in eastern Newfoundland coincides with the greatest concentrations of capelin.

The effects of a recent increase in the number of shad *(Alosa sapidissima)* and "river herring" *(A. pseudoharengus* and *A. aestivalis)* due to river restorations need to be examined since recent by-catches in shad-targeting gillnets have been reported. The stomach contents of these porpoise need to be examined to determine the importance of this food resource recently reported in the porpoise diet.

PREDATORS

Due to their small size, harbor porpoise may be affected by a number of large predators (WP 7). Harbor porpoise remains have been found in stomachs of several white sharks *(Carcharodon carcharias)* collected from the Bay of Fundy (Arnold 1972). Other large predatory sharks such as the mako *(Isurus oxyrinchus)* and tiger, *(Galeocerdo cuvieri)* are known to overlap in distribution with harbor porpoise, although no reports of harbor porpoise predation by these species exist. Smaller sharks may be responsible for some harbor porpoise mortality, since seal pups on Sable Island were observed to experience sizable losses due to attacks by small sharks (Brodie and Beck, 1983).

Sightings of killer whales in the Northwest Atlantic are infrequent but Lien, *et al.* (in press) suggested that small numbers of killer whales may be regular visitors to the northeastern Gulf of St. Lawrence. Killer whales have not been reported to prey upon harbor porpoise in these waters but the potential cannot be discounted since killer whales are known to attack other cetaceans in these regions (Sergeant and Fisher 1957) and attacks on harbor porpoise have been photo-documented in the Northeast Pacific (Leatherwood, *et al.* 1982).

The abundance of predators in these areas is not well known. There are several regional commercial fisheries (*e.g.* swordfish gillnets, swordfish longline, sink gillnets, herring weirs, *etc.*) that have a by-catch of sharks. In addition, there is a sport fishery that targets large sharks (mako, white, tiger, *etc.*). The effects of these removals on the abundance of sharks are unclear, but it is likely that the abundance of some predators has declined. Our current understanding of the relationships between harbor porpoise and their predators is limited.

DIRECT HUMAN- INDUCED MORTALITY

The workshop reviewed data available on incidental catches of harbor porpoise in the northwest Atlantic, North Carolina to Labrador. This review was intended to identify the fisheries involved, and the availability of data on incidental catches for each. In addition, the workshop reviewed current estimates of incidental catches from different regions and discussed the potential errors in these estimates. Finally, the workshop provided suggestions for future research to improve monitoring and analysis of fishery induced mortality.

Table 1 lists the fisheries that have the potential to take porpoise from North Carolina to Labrador, along with a synopsis of available data. The workshop noted that although harbor porpoise are known to be a by-catch in many of these fisheries, no by-catches have been reported for some. Known by-catches are associated primarily with gill net fisheries.

GULF OF ST. LAWRENCE

Kingsley provided a review of the data available on incidental catches in the Gulf of St. Lawrence (Fontaine, *et al.* in press). In 1989 and 1990 mail surveys were conducted in the Quebec region (northern Gulf, western Gulf and St. Lawrence estuary). Survey forms were mailed to all 'fixed gear' permit holders, each permit holder being asked to report the number of porpoise caught in the previous fishing season. The total catch was estimated by scaling the reported catch by the proportion of permit holders who responded. Peak catches were found to occur during July and August, which are also the months of greatest fishing effort. More than 90% of the catches occurred in groundfish gillnets, while a small amount occurred in pelagic gillnets. Eastern Gaspé, Honguedo Channel, and the Lower North Shore were identified as areas of relatively high catch. The results of these surveys are shown in Table 2.

In 1991 a similar questionnaire was sent to permit holders in the southern and eastern Gulf of St. Lawrence. Owing to the large number of permit holders, questionnaires were sent to a systematically chosen subsample of one-third of the holders. Of 3,855 permit holders listed, 1,285 questionnaires were sent and 264 were returned. Of this number, 60 to 65 porpoise were reported to have been caught. Based on this catch, 876 to 949 porpoise were estimated to have been caught in this region. A telephone follow-up study is currently underway.

Combining the estimates for 1988 in the Quebec Region and 1990 for the Gulf Region results in a minimum reported catch of 663 porpoise per year and an estimate of total incidental take of ~2,700. However, it was noted that this estimate is subject to non-response bias (which may be large), errors in remembrance, or misreporting. The direction of any potential bias in the estimates of the catch rate is unknown.

NEWFOUNDLAND

Stenson (WP 31) provided a review of current estimates of incidental catches in Newfoundland. In 1990, a telephone survey was undertaken to estimate the catch rate of porpoise during 1989. A total of 235 fishermen (heads or former heads of fishermen committees), located in separate villages, were interviewed. An additional 115 could not be contacted even after repeated attempts. Information on gear types used, fishing effort, and total by-catch was requested. Due to potential errors in species identifications, all small cetaceans were grouped. Animals identified as 'porpoise' or 'harbor porpoise' accounted for the majority of the small cetaceans identified.

Table 1. Summary of information available on fisheries using gear known to kill harbor porpoise in U.S. and Canada in eastern North America, including general area, fishing gear, specific region (U.S. statistical areas where appropriate), by-catch level, source of information, years for which data are available, and U.S. category under the Marine Mammal Protection Act relating to expected severity of by-catch of marine mammals (I greatest, III least).

Area Gear	Gear	Region	Level	Source	Data Available	Cat
Gulf of Maine	sink gillnet	511-515	$\neq 0$	workshop	1989-92	I
					1984-85	
	surface gillnet	511-515	$\neq 0$	Gilbert & Wynne, 1987	1984-86 Gilbert 1987	I
	stop seine	511-514	$\neq 0$	NMFS (1992)		III
Georges Bank Nantucket Shoals	sink gillnet	521-522	- 0	workshop	1989-92	I
Northeastern U.S.	trawl		- 0	workshop	1989-92	III
	driftnet	offshore	- 0	NMFS (1992)	1989-92	I
	pair trawl		unk			II
	purse seine		unk			III
S. New England	sink gillnet	537-539	$\neq 0$	workshop	1992	I
	shad gillnet	612-614	$\neq 0$	NMFS (1992)		II
Mid-Atlantic Bight	pelagic trawl		- 0	Waring *et al.* (1992)	1986-92	I
NC to NY	coastal gillnet		$\neq 0$	NMFS (1992)		II
Bay of Fundy	sink gillnet		$\neq 0$	workshop	1986-91	
	herring weir	eastern	$\neq 0$	Read (pers. comm.)		
	herring weir	western	$\neq 0$	workshop	1969-91	
	herring purse seine		unk			
	trawl		unk			
Scotian Shelf	gillnet		unk			
Nova Scotia	mackerel	eastern	$\neq 0$	Beck (pers. comm.)		
Gulf of St. Lawrence	gillnet		$\neq 0$	workshop	1988-91	
	trawl		unk			
Newfoundland	sink gillnet	inshore	$\neq 0$	workshop	1989-92	
	sink gillnet	offshore	- 0	workshop	1989-92	
					1988-92	
	salmon nets		$\neq 0$	workshop	1989-91	
	traps		$\neq 0$	workshop	1989	
	trawl		$\neq 0$	workshop	1988-92	
	purse seine		- 0	Lien *et al.* (in press)	1989	

Table 2. Results of mail surveys of harbor porpoise by-catch conducted in the Quebec Region of the Gulf of St. Lawrence

Year	No. of Surveys Mailed	No. of Surveys Returned	Reported Catch	Total Estimated Catch
1988	968	316	623	1908
1989	731	135	326	1765

Table 3. Estimated catch of small cetaceans in Newfoundland during 1989

Gear Type	No. of Fishermen	Catch per Fisherman (SD)		% Fishermen Catching 1+
Groundfish gillnet	190	0.91	(3.57)	16
Salmon gillnet	74	0.27	(0.89)	11
Lumpfish gillnet	109	0.05	(0.40)	3
Codtrap	135	0.01	(0.08)	1
Trawl	91	0.01	(0.10)	1

The majority of catches occurred in groundfish gillnets (Table 3). Small cetaceans were also caught in salmon gillnets, occasionally in lumpfish gillnets, and rarely in cod traps and trawls. No by-catch was reported for capelin traps or seines. The majority of respondents reported no by-catch although a few caught large numbers (up to 30). High levels of catches were reported in the Fogo/ Twillingate, Fortune and St. Mary's Bay areas.

Lien, *et al.* (in press) identified some of the potential sources of error associated with these estimates of by-catch. The frequency of reported catches were not randomly distributed; catches greater than five were clustered. Also, significant differences were found in the reported catch rates among interviewers; larger landings and incidental catch rates were reported to interviewers with previous fisheries experience. The reason for this bias is unknown.

A follow-up interview study (Lien, *et al.* in press) found that a number of the respondents changed their estimates in a random direction. The degree change was proportional to the initial by-catch reported.

Although an estimate of total catch could be made by scaling these catch rates using the total number of licensed fishermen, this estimate was considered to be of no practical value due to the potential sources of error observed in the data, the selection of respondents, and uncertainties in the number of active (*vs.* licensed) fishermen.

Since 1988, fisheries observers placed on offshore boats have been requested to report all by-catch of marine mammals. Only 1 porpoise was reported caught in 27,000 observed sets made by the otter trawl fleet in 1988. A small gillnet fleet also operates in the same area. No porpoise were reported in the 304 observed sets made in 1988; data collected since 1988 have not been analyzed.

BAY OF FUNDY AND EASTERN NOVA SCOTIA

Monitoring of incidental catches in sink gillnet fisheries along the New Brunswick side of the Bay of Fundy has been carried out since 1986 (WP 7, WP 28). In recent years, however, estimates have not been obtained due to the lack of cooperation among fishermen. Estimates of incidental catches from gillnets have ranged from 94 to 116 for 1986, to 130 for 1989. In addition to gillnet catches in New Brunswick, weir fisheries, and surface gillnets in the U.S. and Canadian waters may take an additional 50 animals (WP 7). The frequency of catches by individual fishermen was highly skewed. A likely minimum estimate of by-catch in this region is approximately 150 porpoise per year.

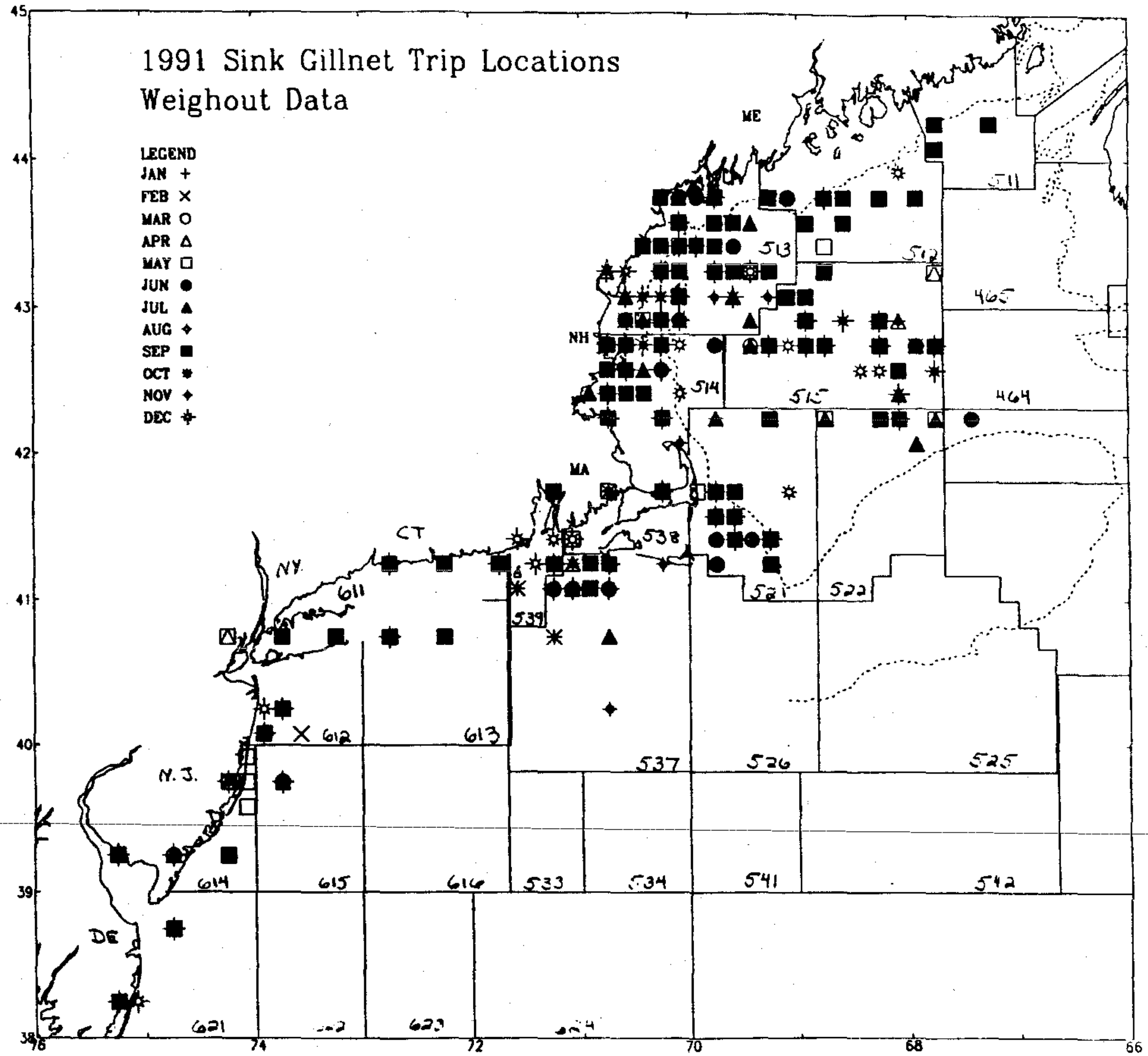
No data were available on the catch rates of porpoise in gillnets fished in southwest Nova Scotia. It was noted that this fishery is primarily directed towards hake, and occurs in deeper water than along the New Brunswick side.

No information is available about incidental catches of porpoise in fisheries carried out along eastern Nova Scotia. An anecdotal report of incidental catches in the April Cape Breton mackerel fishery was noted.

GULF OF MAINE

Estimates of incidental catches in sink gillnets in the Gulf of Maine are summarized in WP 12. The Northeast Fisheries Science Center (NEFSC) Sea Sampling (SS) Program has collected data on fishing activity and marine mammal interactions since June 1989 using trained observers aboard selected fishing vessels. These data are used to

Figure 2. Location of 1991 sink gillnet trips recorded in the weighout (WO) with boundaries of the statistical areas used in recording data on fishing activity and catches.



estimate the catch rate of porpoise which can be expressed in terms of catch-per-trip or catch-per-total-landings. The total number of observer-sea days are allocated proportionally (by month and statistical area, Figure 2) based on total vessel days absent, as estimated by the NEFSC port agents and recorded in the NEFSC weighout (WO) data files. Prior to June 1991, observer coverage was approximately 1% of the total effort in statistical areas 521 and lower. Since that date, coverage has been increased to 10% of the total estimated effort.

NEFSC plans the number of trips to be sampled by area and time. Selection of the actual observers and vessels is done by a contractor to meet the time and area requirements. Two factors make the selection of vessels nonrandom. The first is that not all vessels are considered for selection. Vessels are considered only if they are large enough to accommodate an observer, can provide sufficient work space, and meet minimum safety requirements. It was noted that 70 to 80% of the fleet met these criteria. If true, this suggests the bias may be small due to this component of nonrandomness; there was uncertainty, however, about the basis for and validity of these figures. Secondly, the selection of vessels in the eligible pool is not random because of factors including the working relationship between the contractor and the skipper. This could introduce bias in the estimates of the average porpoise by-catch rate, but the direction of any potential bias has not been estimated to date. It was also noted that no vessel has been known to refuse an observer, although it was not clear what would constitute an actual refusal, or if some consideration of acceptance is made prior to approaching a vessel. The question of a bias in selection occurring due to a higher probability of refusal for vessels fishing in certain areas (*e.g.* no room available on offshore boats) was raised. Bisack noted that of 136 vessels selected, 21 were used between 10 and 19 times while 35 were used between 5 and 10 trips. The remaining 80 were selected for 5 trips or fewer.

The workshop felt that the apparent tendency to select certain vessels should be investigated further to determine if it introduces any bias in the SS data, although it recognized that the small sample size may make this difficult to do at this time. Some variables that need to be examined in the future include seasonality of fishing, port, size of vessel, amount of gear used, location of fishing, and total landings.

The Gulf of Maine (GOM) study area was defined as Statistical Areas 511-515. Although data were available for the Georges Bank and Nantucket Shoals gillnet fishery (Statistical Areas 512-522), these were excluded since no by-catches have been observed there. The SS data was stratified into two areas (statistical areas 511 and 512 (N. GOM) versus areas 513, 514, and 515 (S. GOM)) and three time strata (January-May, June-August, September-December). The stratification scheme was chosen in an attempt to account for assumed migratory patterns of porpoise. Further stratification into specific statistical areas was not done due to the low sampling frequency in some areas and the potential of misreporting trips among areas. The possibility of including data for trips made in area 521, which is not included in the analysis, to 514 was raised. The workshop also suggested that the sensitivity of the results to misreporting and changes in stratification be examined.

No direct measures of effective fishing effort were available (Gilbert and Wynne, 1987) which could be used as expansion factors to estimate total porpoise by-catch in the region. Therefore, two indirect measures were used; number of trips and total landings. Total number of trips and landings for the entire fleet were obtained from the NEFSC weighout data files. In this program, port agents collect information on landings and fishing activity from sales receipts and/or interviews with the fishermen. Neither measure of fishing activity is a complete census (WP 12 addendum), although total landings were considered to be more accurate than number of trips (Anonymous, 1992). The workshop noted that total incidental take based on by-catch per trip and its associated variance would be underestimated if the number of trips was underestimated. The estimate based on total landings would be an underestimate if the landings are underestimated in the weigh-out (WO) data, but its variance would not be affected. If the trips are estimated as suggested here, then the variance of the estimate based on total landings would be underestimated since trips enters into the variance formula.

The total by-catch estimated by both methods may be incorrectly estimated (and the precision underestimated) if misallocation of catch to gear occurs (WP 12). There is anecdotal evidence of a switch from gillnets to longlines, which do not catch porpoise. However, it is unknown if this switch was correctly identified in the WO data. The workshop suggested that the SS observers be requested to provide more detailed information on the observed trip and that any gear changes be tracked in the WO database to see if they are identified.

The estimated total by-catch varied depending upon the estimator used (Table 4). Generally, estimates based on landings were similar or greater than those based on trips. One exception occurred but it was noted that this was based on a small sample size of observed trips (n=2). The majority of by-catch occurred in the southern strata, primarily in the fall and winter. By-catch occurred in the summer and fall strata in northern areas.

Assuming WO catch rates similar to those observed in the SS data, the total number of trips that would have been required to obtain the observed WO landings was estimated. If the landings data are correct, this suggests the magnitude of the number of trips that may have been missed (WP 12). In addition, trips that occurred in the SS data were tracked in the WO data. For those trips that could be tracked, there was some evidence of bias in the visual estimates of landings recorded by the observer. The workshop noted that errors in estimating landings by the

Table 4. Estimated by-catch of harbor porpoise by year, season, and area strata using two methods: that based on recorded number of fishing trips, and that based on recorded number of landings, with standard deviations of the estimates (This table taken from WP12, Table 5)

		Trips				**Landings**			
		N. Gulf of Maine		**S. Gulf of Maine**		**N. Gulf of Maine**		**S. Gulf of Maine**	
		$\hat{k}$	**SD**	$\hat{k}$	**SD**	$\hat{k}$	**SD**	$\hat{k}$	**SD**
1989	Summer[1]	0	0	0	0	0	0	0	0
	Fall[2]	0	0	372	170.1	0	0	337	174.2
1990	Winter[3]	0	0	495	217.0	0	0	1264	158.8
	Summer	0	0	0	0	0	0	0	0
	Fall	217	216.0	748	298.2	87	399.6	1045	347.1
1991	Winter	0	0	748	294.0	0	0	1201	331.0
	Summer	57	28.3	18	16.7	65	27.9	19	16.6
	Fall	39	20.9	281	55.6	48	21.9	339	60.9

[1] Summer (June-August)
[2] Fall (September-December)
[3] Winter (January-May)

observers would affect the estimated by-catch and that the extent of this potential source of error should be determined.

The impact of a change in the species composition of reported catch should also be explored. For example, Bisack reported that landings of dogfish *(Squalus acanthais)* occurred mainly in areas with low rates of by-catch.

The total estimated by-catch for the complete year are available (1990 and 1991) are shown in Table 5. The estimate for 1990 is based on 1% observer coverage, while the 1991 estimate is based on 1% coverage for the first 5 months and 10% coverage for the last 7 months.

Table 5. Estimated by-catch of harbor porpoise by the U.S. Gulf of Maine sink gillnet fishery in 1990 and 1991, using two methods

	Landings		**Trips**	
	$\hat{k}$	**SD**	$\hat{k}$	**SD**
1991	1672	339	1142	302
1990	2396	467	1460	427

The workshop agreed that the best estimate of by-catch would be obtained based on a more direct measure of effective effort. However, in the absence of such data, it must rely upon an indirect measure. Because of the known errors in estimates of the number of trips and the likely greater accuracy of the total landings data it was concluded that, although there are a number of potential uncertainties associated with it, estimates based on landings were the best estimates of total by-catch. Summing the estimates for each strata in Table 4, for 1990 and 1991 these are approximately 2,400 (95% CI 1,600 to 3,500) and 1,700 (95% CI 1,100 to 2,500), respectively, using a lognormal assumption for computing the confidence intervals. Because the variances of the estimates are underestimated, as discussed earlier, these confidence intervals likely underrepresent the true uncertainty.

The possibility of using other nonratio estimators was discussed. The workshop felt that more complex models for estimating by-catch should be explored, but noted that the sparse data set available for catches may preclude their use at this time. However, it should be attempted once additional data are available based on 10% observer coverage.

SOUTHERN NEW ENGLAND

By-catch of harbor porpoise does occur in the Southern New England sink gillnet fishery. However, observer coverage of this fleet only started in April 1992 and therefore, insufficient data are available to estimate the total extent of this by-catch. The workshop noted that since the techniques used are similar to those used in the Gulf of Maine, all of the potential sources of uncertainty identified previously may apply to Southern New England.

FUTURE RESEARCH

The workshop noted a number of areas where future work is required for a better understanding of incidental catches. These include:

- Improve estimates of by-catch in the Gulf of St. Lawrence, Newfoundland, and southwest Bay of Fundy.

- Develop estimates of by-catch for fisheries that have not been examined, particularly southwest and eastern Nova Scotia and south of Cape Cod.

- Conduct sensitivity analysis of the Gulf of Maine estimates to identified areas of uncertainty, *e.g.* observer sampling schemes, the placement of observers on vessels, the repeated use of vessels, the allocation of observers based on the previous years WO data, misreporting or incorrect allocation of catch and/or effort, species composition of the catch, and the stratification schemes adopted.

- Relate porpoise by-catch to fishing effort and indirect measures of effort such as number of trips or landings, including quantifying the variance introduced by using indirect measures of effective effort.

- Conduct improved analysis of incidental catches on finer spatial scales (*e.g.* area by area) to identify heterogeneity, including developing methods of obtaining better data on fishing location.

- Estimate the potential rate of loss of harbor porpoise from sink gillnet as they are retrieved.

- Investigate the extent of underreporting in the WO of both trips and landings, and the numbers of undertonnage vessels.

- Develop means of projecting by-catch under changes in the fishery.

INDIRECT HUMAN EFFECTS

POLLUTION

The Gulf and estuaries, in general, do not appear to show high levels of contaminants except for a few isolated areas (*e.g.* Baie Comeau and the mouth of the Saguenay River). Although St. Lawrence beluga whales have shown unusually high concentrations of contaminants, this was not reflected in other species of cetaceans (including harbor porpoise). Several reasons were given for these observations; most dealing with contaminant dynamics through the trophic levels.

Coastal pollution was not considered to be a significant problem in Newfoundland. One area of interest is Placentia Bay is in southeastern Newfoundland, a site of a major oil refinery. It is near to areas of high summer concentration of harbor porpoise (Hellou, *et al.* 1990). Analyses of polycyclic aromatic hydrocarbons (PAHs) in harbor porpoise are in progress by Newfoundland researchers.

Harbor porpoise have a high level of lipid in their blubber, therefore, this tissue may accumulate high concentrations of certain lipophilic contaminants such as organochlorines (OCs). Although OCs are present in blubber of Bay of Fundy harbor porpoise, no pathological effects have been observed.

It is important to study the dynamics of OC transfer from prey species to porpoise and from mothers to calves during lactation since calves have been observed to carry high concentrations of OCs. Comparisons between stranded animals and incidentally caught animals may provide some insights into possible causes of mortality. Suppression of reproductive or immune systems by contaminants need to be examined.

Analyses of levels of organochlorines and heavy metals in porpoise collected from the Bay of Fundy, Gulf of Maine, Gulf of St. Lawrence and Newfoundland are being conducted by A. Westgate and D. Johnson, respectively (University of Guelph). Caution must be taken when comparing historical data with present data since the sensitivity of current measurement technology is much greater. Brodie suggested measuring levels of the mix function oxidase (MFO) enzyme for signs of toxic shock.

PHYSICAL HABITAT REDUCTION

The increased number of salmon aquaculture operations in the sheltered bays and coves in the southwest Bay of Fundy has coincided with the observed disappearance of harbor porpoise from these areas (Gaskin and Watson 1985). Dredging operations and the use of explosives in Boston Harbor may affect the behavior of harbor porpoise. The greatest problem may be vessel

Table 6. Information available for possible criteria relative to the status of harbor porpoise in three putative populations in northeastern North America. YES indicates that sufficient information is available, NO indicates that insufficient information exists, and NO* indicates that sufficient information may exist, but that further evaluation would be required.

Criteria	**Population Hypothesis I**		
	Newfoundland	**Gulf of St. Lawrence**	**Bay of Fundy/ Gulf of Maine**
Abundance relative to previous abundance	No	No	No
Trophic interactions	No*	No*	No*
Removals	Yes	Yes	Yes
Population trends	No	No	No*
Change in vital rates	No	No	Yes
Disease and predation	No	No	No
Habitat changes *(not including prey and sink gillnets)*	No	No	No
Economic and social factors	No*	No*	No*
Adequacy of regulatory structure	Yes	Yes	Yes
Species precedents	Yes	Yes	Yes
Ecosystem role	Yes	Yes	Yes

traffic, since the number of boats in the Gulf of Maine has increased dramatically and harbor porpoise have been observed to avoid boats (WP 20). The small sheltered bays in the Gulf of Maine where calving or nursing may occur are probably experiencing similar increases in boat traffic. The difference between vessel avoidance behavior and area avoidance by harbor porpoise, due to boat traffic, was noted. Also, the amount of time spent avoiding boats is important, since foraging time may be reduced. Small, high-speed vessels are possibly of greater concern than larger vessels, except in situations where large commercial ships may physically displace animals from small sheltered areas.

In Puget Sound, it has been speculated that the observed decrease in porpoise numbers was due, in part, to increased vessel traffic. Conversely, several areas in California (Monterey Bay, San Francisco Bay, *etc.*) experience high boat traffic but still maintain high concentrations of harbor porpoise. It is important to note that these are also highly productive areas. Even though porpoise may inhabit these high traffic areas, it can not be concluded that porpoise are not affected by the traffic. If highly productive areas are limited, avoidance of these areas may not be possible.

STATUS OF POPULATIONS

The status of populations can be considered under different criteria, including those used in Canada, applied by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in assigning a "threatened" status to harbor porpoise (WP 28); and those used in the United States, specified under the Marine Mammal Protection Act, the Endangered Species Act, and the Fisheries Conservation and Management Act (WP 1). The workshop reviewed the legal bases for management in the two countries, and assembled a list of criteria under both U.S. and Canadian laws to determine which criteria could be addressed with information reviewed during the workshop (Table 6). Those criteria for which sufficient information was judged to be available (indicated by Yes) will be discussed further. Those criteria for which insufficient information is available (indicated by No) are not discussed further. However, the workshop noted that information exists relative to some of these latter criteria, and recommended that such information be evaluated relative to the status of harbor porpoise. Those are indicated by No*.

These criteria are evaluated for each of the three putative populations under the preferred population structure hypothesis. The workshop noted, however, that the alternate hypothesis of one population in northeastern North America could not be rejected (see the section on population structure, page 3). Because of this, the workshop cautioned that any interpretation of the available information would be substantially more difficult under that hypothesis, and the conclusions would possibly be different.

REMOVALS

The workshop concluded that the current best estimates for the by-catch of harbor porpoise by sink gillnets in U.S. waters of the Gulf of Maine are approximately 2,400 in 1990 and 1,700 in 1991. There are a large number of caveats pertaining to these estimates and their estimated variances, discussed in the section on direct human induced mortality, page 12. The best available estimates of the size of the population in 1991 in the Gulf of Maine and Bay of Fundy, based on a summer survey, is approximately 45,000 animals, with caveats described in the section on population sizes, page 8. A complete abundance survey was not carried out in 1990, and the 1991 population estimate is currently the best estimate of the population size in 1990 as well.

The ratio of the estimate of U.S. Gulf of Maine by-catch to the estimate of population size are estimates of the annual mortality rates due to the U.S. Gulf of Maine sink gillnet fishery. These rates are approximately 0.05 in 1990 and 0.04 in 1991. Given the estimated variances of these quantities, the 95% confidence intervals (based on a lognormal assumption) are 0.026 to 0.109 in 1990, and 0.018 to 0.077 in 1991.

The workshop noted that these rates are only for the U.S. Gulf of Maine sink gillnet fishery. Estimates are needed for other fisheries impacting this population (see section on direct human induced mortality, especially Table 4). However, it was noted that this component of the human impact may be greater than the recommendations made by the Scientific Committee of the International Whaling Commission of a maximum mortality rate for harbor porpoise (see WP 25). The analyses recommended in the discussion of vital rates (page 6) for estimating potential rates of increase would improve the accuracy of this comparison.

Estimates of by-catch rates for Newfoundland and the St. Lawrence exist. They are based on designed programs of data collection and analysis. Both are based on the individual fisherman's year-round experience as a sampling unit. Estimates of total by-catch in both areas are suspect because of the probable existence of substantial sampling bias, lack of information on the population of fishermen, or both.

For the Gulf of St. Lawrence, a minimum reported by-catch of the order of 700 can be deduced from questionnaire survey returns. For Newfoundland, the minimum reported catch is about 170 for groundfish gillnet. For neither area are there population estimates against which to evaluate the by-catches.

CHANGES IN VITAL RATES

Changes in vital rates of harbor porpoise from the Bay of Fundy have been documented by comparing samples obtained over a 15-year time period. The most notable changes were a reduction in the mean age of sexual maturation of females and an increase in the growth rate of juveniles. These changes are consistent with at least two alternative hypotheses: (1) that the porpoise population was reduced by incidental catches or other factors, leading to an increase in *per capita* food consumption; and (2) that changes in prey biomass led to an increase in *per capita* food consumption, regardless of the trajectory of the porpoise population.

There is no information on changes in vital rates of harbor porpoise from other areas of northeastern North America.

ADEQUACY OF REGULATORY STRUCTURE

In the U.S., the MMPA under its current marine mammal exemption program, combined with the Endangered Species Act requirements, provides a full range of regulatory mechanisms that may adequately protect most marine mammals in the U.S. However, given our current understanding of the level of by-catch in the Gulf of Maine sink gillnet fishery, there is some concern that the present regulations do not contain an upper limit to by-catch, and may be inadequate.

The Committee on the Status of Endangered Wildlife in Canada has assigned a threatened status to the harbor porpoise in eastern Canada. While such designations have no direct legislative consequences, they may be taken into account by many agencies in decision-making processes.

The Minister of Fisheries and Oceans has general powers, under the Fisheries Act, to close and regulate fisheries. Under the Cetacean Protection Regulations, the minister may take other action specifically to protect cetaceans. All commercial fisheries for cetaceans have been closed.

SPECIES PRECEDENTS

Harbor porpoise were once abundant and are now very rare in southern Puget Sound, San Francisco Bay, and the Baltic Sea (WP 25; Barlow and Hanan in press). Significant declines, but of lesser magnitude, have been seen in the English Channel and in the southern North Sea (WP 25).

Human factors (including by-catch, directed harvests, and pollution) have been implicated as the most likely cause for these declines. Given these observations, harbor porpoise appear vulnerable to human impacts. Management of this species should take this vulnerability into consideration.

ECOSYSTEM ROLE

The U.S. Marine Mammal Protection Act calls for populations to be maintained at levels where they remain functional elements of the ecosystem. The actual trophic level interactions that could quantify the functional capacity of harbor porpoise were not available for the workshop. However, the workshop noted that these interactions may eventually be described throughout its range. The workshop concluded that, given the present estimated or observed population levels in the three areas of summer concentration, the observed vital rates of individual animals found in these areas, and the apparent large biomass of available prey species for harbor porpoise, the species has been able to maintain itself as a functioning element of the ecosystem in which it lives, notwithstanding the various anthropogenic factors that may be affecting the species/populations adversely. It is not known whether it has been forced to take a reduced role in the ecosystem, or has been able to elevate itself to a larger role than it had been in past years.

CONCLUSIONS

Noting that the ratio of by-catch mortality to population size for harbor porpoise in the Gulf of Maine and Bay of Fundy population is close to the maximum allowable take levels suggested by the International Whaling Commission Scientific Committee, and that other removals are known to occur, **the workshop recommends that the level of by-catch be reduced.**

Noting that insufficient information is available to assess the impact of the by-catch of harbor porpoise in Newfoundland and the St. Lawrence, and given the potential magnitude of these by-catches, **the workshop recommends that surveys of abundance be initiated and that estimates of by-catch be improved.**

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Appendix 1: Invited Workshop Participants

Dr. Jay Barlow, Southwest Fisheries Science Center, La Jolla, Cal.
Ms. Kathryn Bisack, Northeast Fisheries Science Center, Woods Hole, Mass.
Dr. Paul Brodie, Department of Fisheries and Oceans, Halifax, Nova Scotia
Dr. Jon Brodziak, Northeast Fisheries Science Center, Woods Hole, Mass.
Dr. Kenneth Burnham, Colorado State University, Ft. Collins, Colo.
Dr. Hal Caswell, Woods Hole Oceanographic Institute, Woods Hole, Mass.
Dr. James Gilbert, University of Maine, Orno, Maine
Mr. Scott Kraus, New England Aquarium, Boston, Mass.
Dr. Michael Kingsley, Department of Fisheries and Oceans, Mt. Joli, Quebec
Mr. Ralph Mayo, Northeast Fisheries Science Center, Woods Hole, Mass.
Ms. Debra Palka, Northeast Fisheries Science Center, Woods Hole, Mass.
Mr. Michael Payne, National Marine Fisheries Service, Silver Springs, Md.
Dr. Andrew Read, Woods Hole Oceanographic Institute, Woods Hole, Mass.
Ms. Patricia Rosel, Southwest Fisheries Science Center, La Jolla, Calif.
Dr. Andrew Rosenberg, National Marine Fisheries Service, Silver Springs, Md.
Dr. Tim Smith, Northeast Fisheries Science Center, Woods Hole, Mass.
Dr. Gary Stenson, Department of Fisheries and Oceans, St. Johns, Newfoundland
Mr. John Wang, University of Guelph, Guelph, Ontario

Appendix 2: Working Papers

WP 1
Smith, T.D. 1991. Overview of the assessment of harbor porpoise status. SAW/13/SARC/4. Woods Hole: NMFS Northeast Fisheries Science Center. Available from: NEFSC, 166 Water St., Woods Hole, MA 02543.

WP 2
Wang, J.Y., D.E. Gaskin and B.N. White. 1992. Genetic analysis of harbour porpoise. *Manuscript.*

WP 3
Rosel, P. 1992. Preliminary genetic analysis of harbor porpoise population structure in the north Atlantic. *Manuscript.*

WP 4
Polacheck, T., F.W. Wenzel and G. Early. 1991. What do stranding data say about harbor porpoise *(Phocoena phocoena)*? *IWC working paper* SC/42/SM 39.

WP 5
Palka, D., A.J. Read, D.C. Potter, and J. Nicolas. 1992. A pilot study of the migration patterns and life history parameters of harbor porpoise found along the Maine coast. *Manuscript.*

WP 6
Woodley, T.H. and A.J. Read. In press. Potential rates of increase of a harbour porpoise *(Phocoena phocoena)* population subjected to incidental mortality in commercial fisheries. *Can. J. Fish. Aquat. Sci.*

WP 7
Brodie, P. 1992. Status, energetics and incidental by-catch mortality of harbour porpoise in the Gulf of Maine/Bay of Fundy. *Manuscript.*

WP 8
Berggren, P., A.J. Read, and D. Gaskin. 1992. Change in relative abundance of harbor porpoise in Bay of Fundy during the last decade. To be submitted to *Fish. Bull.*

WP 9
Power, G.R. and S.C. Drew. 1991. Observer coverage and entanglements of marine mammals in the Gulf of Maine/George's Bank sink gillnet fishery. Woods Hole: NMFS/Northeast Fisheries Science Center. NEFSC SAW/13/SARC/11. Available from: NEFSC, 166 Water St., Woods Hole, MA 02543.

WP 10
DiNardo, G. and K. Bisack. 1992. Logbook verification: Gulf of Maine (GOM) sink gill net fishery. *Manuscript.*

WP 11
Bisack, K. and G. DiNardo. 1991. Estimating total effort in the Gulf of Maine sink gillnet fishery. Woods Hole, MA: Northeast Fisheries Science Center. NEFSC SAW/13/SARC/7. Available from: NEFSC, 166 Water St., Woods Hole, MA 02543.

WP 12
Bisack, K. In review. Estimates of total U.S. harbor porpoise by-catch in the Gulf of Maine sink gillnet fishey. *Northeast Fisheries Science Center Reference Document.* .

WP 13
Bisack, K. 1992. Gill net fishing activity in the Gulf of Maine as reflected in the NEFSC weighout database: 1982-1991. *Manuscript.*

WP 14
number not used

WP 15
Smith, T.D., D. Palka, K. Bisack and G. DiNardo. 1991. Preliminary estimates of harbor porpoise abundance and by-catch. Woods Hole, MA: Northeast Fisheries Science Center. *Northeast Fisheries Science Center Reference Document* 91-04. Available from: Northeast Fisheries Science Center, 166 Water St., Woods Hole, MA 02543.

WP 16
Palka, D. and D. Potter. In review. Cruise report of the Atlantic harbor porpoise harbor porpoise shipboard survey - 1991. *Northeast Fisheries Science Center Reference Document.*

WP 17
Read, A.J. and S.D. Kraus. In review. Harbor porpoise distribution and relative density in the waters of coastal Maine. *Northeast Fisheries Science Center Reference Document.*

WP 18
Potter, D. and D. Palka. In review. Cruise report of the 1991 aerial harbor porpoise survey in the Gulf of Maine. October 11-24, 1991. *Northeast Fisheries Science Center Reference Document.*

WP 19
Palka, D. In review. Effects of Beaufort sea state on the sightability of harbor porpoise in the Gulf of Maine. *Northeast Fisheries Science Center Reference Document.*

WP 20
Palka, D. In review. Evidence of harbor porpoise avoiding the sighting platform *R/V Abel-J. Northeast Fisheries Science Center Reference Document.*

WP 21
Polacheck, T. and L. Thorpe. 1990. The swimming direction of harbour porpoise in relationship to a survey vessel. *Rep. Int. Whal. Commn* 40:463-470.

WP 22
Palka, D. In review. Estimates of g(0) for harbor porpoise groups found in the Gulf of Maine. *Northeast Fisheries Science Center Reference Document.*

WP 23
Palka, D. In review. Abundance estimate of the Gulf of Maine harbor porpoise. *Northeast Fisheries Science Center Reference Document.*

WP 24
Anon. 1992. Report of the Thirteenth Northeast Regional Stock Assessment Workshop. WoodsHole, MA: Northeast Fisheries Science Center. *Reference Document* 92-02. [pages 31-38].

WP 25
IWC. 1991. Appendix G: Report of the Sub-Committee on Small Cetaceans. Report of the Scientific Committee. *IWC Reports* IWC/42/4, International Whaling Commission, Cambridge England.

WP 26
IWC. 1991. Appendix G: Report of the Scientific Committee, section 5.2.5. *IWC Reports* IWC/43/4, International Whaling Commission, Cambridge, England.

WP 27
Bjorge, A., H. Aarefjord, S. Kaarstad, L. Kleivane, and N. Øien. 1991. Harbour porpoise *Phocoena phocoena* in Norwegian waters. *ICES C.M.* 1991/N:16.

WP 28
Gaskin, D.E. 1991. Status report on the harbour porpoise *Phocoena phocoena*. Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ont.

WP 29
Lazar, N. and J. DeAlteris. 1992. Summary of the survey of the demersals gillnet fishery in the Gulf of Maine and adjacent waters. Manuscript with letter of transmittal, Dept. of Fisheries, Animal and Veterinary Science, Univ. of Rhode Island.

WP 30
same as WP 13

WP 31
Stenson, G. and S. Richardson. 1992. Progress report on harbor porpoise research in Newfoundland Region. *Manuscript.*

WP 32
Stenson, G.B., E. Perry, and D.G. Reddin. 1992. Incidental catches of marine mammals and seabirds in experimental salmon drift nets in west Greenland. *Manuscript.*

WP 33
Richardson, S.F. and G.B. Stenson. 1992. Growth and reproduction of the harbor porpoise around eastern Newfoundland: preliminary results. *Manuscript.*

WP 34
Stenson, G.B. and D.G. Reddin. 1991. Incidental catches of small cetaceans in drift nets during salmon tagging experiments in the Northwest Atlantic. *Manuscript.*

WP 35
Anon. 1992. Harbor porpoise working group draft action plan. *Manuscript.*

Appendix 3: Agenda

Northeast Atlantic Harbor Porpoise Workshop
Aquarium Conference Room
Northeast Fisheries Science Center
Woods Hole, MA 02543

May 5 - 8, 1992

Tuesday, May 5

9:00	Welcome (Aquarium Conf. Room)	S. Clark K. Sherman
9:15	Adoption of Agenda Terms of Reference Structure of Report Establishment of Working Groups, Assigning Rapporteurs	T. Smith
9:30	Distribution (Aquarium Conf. Room)	
12:00	Lunch	
1:30	Population Structure Working Group (Bigelow 217)	
	Vital Rates (Aquarium Conference Room)	

Wednesday, May 6

9:00	Population Size and Trends (Lilly 103)	
	Direct Human Induced Mortality (Aquarium Conference Room)	
12:00	Lunch	
1:00	Continue	
3:30	Review Reports on Population Structure and Vital Rates (Aquarium Conf. Room)	

Thursday, May 7

9:00	Ecological Relationships (Aquarium Conf. Room)	
	Indirect Human Effects (Aquarium Conf. Room)	

12:00 Lunch

1:00 Review Reports on Population Size and Mortality
(Aquarium Conf. Room)

3:30 Status of Populations
(Aquarium Conf. Room)

Friday, May 8

9:00 Review Reports on Ecological Relationships, and Indirect Mortality and Status of Populations
(Aquarium Conf. Room)

10:00 Information Needs and Research Plans
(Aquarium Conf. Room)

Table A1. Working Group (WG) definitions

WG No.	Title	Charge
1	Population Structure	Develop a set of hypotheses about the population structure of harbor porpoise in eastern North America and identify key data needed to discriminate among them.
2	Vital Rates	Review the technical details and determine the most likely range of values for the intrinsic rate of increase for harbor porpoise, as might be observed under optimal conditions.
3	Population Size and Trends in Abundance	Review the technical details and determine the most likely estimates of abundance for the northern Gulf of Maine and Bay of Fundy during the summer, and for other areas as information is available.
4	By-Catch Levels	Review the technical details and determine the most likely estimates of by-catch in the Gulf of Maine, and in other areas as information is available.

Table A2. Assignment of workshop participants to working groups

Participant	Working Groups[1]			
	Population Structure	Vital Rates	Population Size and Trends	By-Catch Level
Barlow		X	C	
Bisack		X		X
Brodie		X		X
Brodziak		R		X
Burnham			X	
Caswell		C	X	
Gilbert				X
Kraus	C		X	
Kingsley	R			X
Mayo		X		X
Palka	X		R	
Payne	X			X
Read		X	R	
Rosel	X			
Rosenberg				C
Smith	X		X	
Stenson	X			R
Wang	X			

[1] X=member, C=chair, R=rapporteur

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Brodie		X		X
Brodziak		R		X
Burnham			X	
Caswell		C	X	
Gilbert				X
Kraus	C		X	
Kingsley	R			X
Mayo		X		X
Palka	X		R	
Payne	X			X
Read		X	R	
Rosel	X			
Rosenberg				C
Smith	X		X	
Stenson	X			R
Wang	X			

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Gilbert				X
Kraus	C		X	
Kingsley	R			X
Mayo		X		X
Palka	X		R	
Payne	X			X
Read		X	R	
Rosel	X			
Rosenberg				C
Smith	X		X	
Stenson	X			R
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